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論　文　内　容　の　要　旨

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論文題名	Neural and Behavioral Dynamics within the Dynamical System with Complex Networks (複雑ネットワークを含む動的システム内の神経および行動ダイナミクス)

論文内容の要旨

Diverse behaviors of animals and their transitions emerge from the complex interactions between the brain and the body, leads to self-organization of attractors and their transitions in the dynamical system with constraints of the structure of the body and the brain. This thesis investigates how the macroscopic structure of the brain affects neural and behavioral dynamics and how the interaction between the neural activities in the network changes according to behaviors, using computational models with complex network theory. First, simulations are conducted using a spiking neural network model to examine how the macroscopic network in the brain is related to the complexity of activity in each region and to functional networks, which is estimated by phase coherence between neural activity in each region. The results of the study showed the following. Local over-connectivity of a neuron group in the network model (1) increases the firing rate of neurons, and therefore, enhances the strength of the connections from excitatory to inhibitory neurons; (2) decreases the complexity of neural activity, while increasing the intensity of specific frequency components of neural activity in a neuron group; (3) increases functional connectivity derived from the synchronization of neural activity.

Second, we conducted a series of simulations using non-linear oscillator networks with different macroscopic networks and a musculoskeletal model (i.e., a snake-like robot) as a physical body, to understand how the coupled neural and behavioral dynamics affect the emergence as well as transitions of behaviors. A behavior analysis (behavior clustering) and network analysis for the classified behavior were then applied. The former consisted of feature vector extraction from the motions and classification of the behaviors that emerged from the coupled dynamics. The coupled dynamics underlying the classified behaviors were revealed by estimating the functional networks using mutual information and transfer entropy. The results showed the following. (1) The number of behaviors and their duration depended on the sensor ratio to control the balance of strength between the body and brain dynamics, as well as on structural properties of certain non-linear oscillator networks. (2) Two types of functional networks underlie two types of behaviors, with different durations, by utilizing complex network theory, a clustering coefficient, and the shortest path length with a negative and a positive relationship with the duration periods of behaviors. Finally, we discuss relationship of our results with those of previous studies and propose future directions.

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論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

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